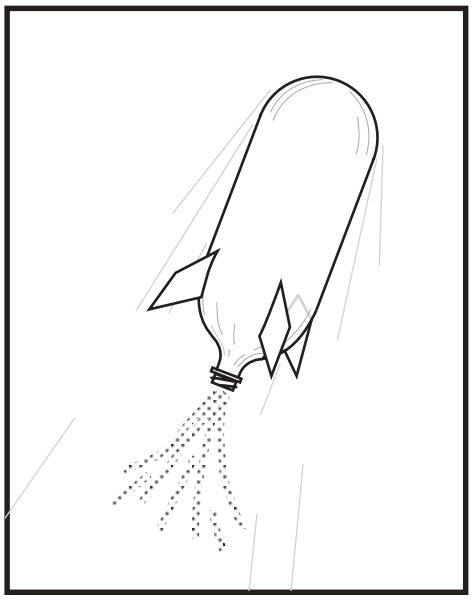


Educator Information

Bottle Rocket Launcher

Objective:
To construct a bottle rocket launcher for use with the *Bottle Rocket* and *Project X-35* activities.

Description:
Students construct a bottle launcher from "off-the-shelf" hardware and wood using simple tools.

Science Standards:
Physical Science - Position and motion of objects
Science and Technology - Abilities of technological design

Science Process Skills:
Measuring

Mathematics Standards:
Mathematical Connections
Measurement

Materials and Tools:

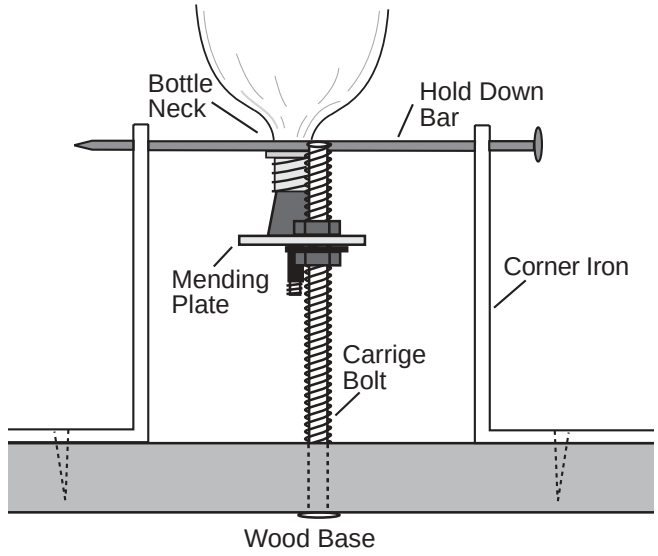
* 4 5-inch corner irons with 12 3/4 inch wood screws to fit
* 1 5-inch mounting plate
* 2 6-inch spikes
* 2 10-inch spikes or metal tent stakes
* 2 5-inch by 1/4 inch carriage bolts with six 1/4 inch nuts
* 1 3-inch eyebolt with two nuts and washers
* 4 3/4-inch diameter washers to fit bolts
* 1 Number 3 rubber stopper with a single hole
* 1 Snap-in Tubeless Tire Valve (small 0.453 inch hole, 2 inch long)
* Wood board 12 by 18 by 3/4 inches
* 1 2-liter plastic bottle
* Electric drill and bits including a 3/8 inch bit
* Screw driver
* Pliers or open-end wrench to fit nuts
* Vice
* 12 feet of 1/4 inch cord
* Pencil
• Bicycle pump with pressure gauge

Management:
Consult the materials and tools list to determine what you will need to construct a single bottle rocket launcher. The launcher is simple and inexpensive to construct. Air pressure is provided by means of a hand-operated bicycle pump. The pump should have a pressure gauge for accurate comparisons between launches. Most needed parts are available from hardware stores. In addition you will need a tire valve from an auto parts store and a rubber bottle stopper from a school science experiment. The most difficult task is to drill a 3/8 inch hole in the mending plate called for in the materials list. Electric drills are a common household tool. If you do not have access to one, or do not wish to drill the holes in the metal mending plate, find someone who can do the job for you. Ask a teacher or student in your school's industrial arts shop, a fellow teacher, or the parent of one of your students to help.

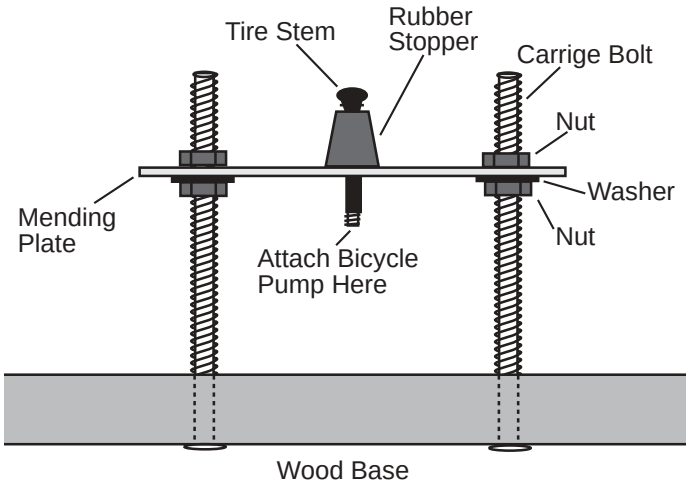
If you have each student construct a bottle rocket, having more than one launcher may be advisable. Because the rockets are projectiles, safely using more than one launcher will require careful planning and possibly additional supervision. Please refer to the launch safety instructions.

Background Information:
Like a balloon, air pressurizes the bottle rocket. When released from the launch platform, air escapes the bottle, providing an action force accompanied by an equal and opposite reaction force (Newton's Third Law of Motion). Increasing the pressure inside the bottle rocket produces greater thrust since a large quantity of air inside the bottle escapes with a higher acceleration (Newton's Second Law of Motion). Adding a small amount of water to the bottle increases the action force. The water expels from the bottle before the air does, turning the bottle rocket into a bigger version of a water rocket toy available in toy stores.

Construction Instructions:
1. Prepare the rubber stopper by enlarging the hole with a drill. Grip the stopper lightly with a vice and gently enlarge the hole with a 3/8 inch bit and electric drill. The rubber will stretch during cutting, making the finished hole somewhat less than 3/8 inches.
2. Remove the stopper from the vice and push the needle valve end of the tire stem through the stopper from the narrow end to the wide end.
3. Prepare the mounting plate by drilling a | 3/8 inch hole through the center of the plate. Hold the plate with a vice during drilling and put on eye protection. Enlarge the holes at the opposite ends of the plates, using a drill bit slightly larger than the holes to do this. The holes must be large enough to pass the carriage bolts through them. (See Attachment of Mending Plate and Stopper diagram below.)
4. Lay the mending plate in the center of the wood base and mark the centers of the two outside holes that you enlarged. Drill holes through the wood big enough to pass the carriage bolts through.
5. Push and twist the tire stem into the hole you drilled in the center of the mounting plate. The fat end of the stopper should rest on the plate.



Positioning Corner Irons



Attachment of Mending Plate and Stopper

6. Insert the carriage bolts through the wood base from the bottom up. Place a hex nut over each bolt and tighten the nut so that the bolt head pulls into the wood.
7. Screw a second nut over each bolt and spin it about half way down the bolt. Place a washer over each nut and then slip the mounting plate over the two bolts.
8. Press the neck of a 2-liter plastic bottle over the stopper. You will be using the bottle's wide neck lip for measuring in the next step.

9. Set up two corner irons so they look like book ends. Insert a spike through the top hole of each iron. Slide the irons near the bottle neck so that the spike rests immediately above the wide neck lip. The spike will hold the bottle in place while you pump up the rocket. If the bottle is too low, adjust the nuts beneath the mounting plate on both sides to raise it.
10. Set up the other two corner irons as you did in the previous step. Place them on the opposite side of the bottle. When you have the irons aligned so that the spikes rest above and hold the bottle lip, mark the centers of the holes on the wood base. For more precise screwing, drill small pilot holes for each screw and then screw the corner irons tightly to the base.
11. Install an eyebolt to the edge of the opposite holes for the hold down spikes. Drill a hole and hold the bolt in place with washers and nuts on top and bottom.
12. Attach the launch "pull cord" to the head end of each spike. Run the cord through the eyebolt.
13. Make final adjustments to the launcher by attaching the pump to the tire stem and pumping up the bottle. Refer to the launching instructions for safety notes. If the air seeps out around the stopper, the stopper is too loose. Use a pair of pliers or a wrench to raise each side of the mounting plate in turn to press the stopper with slightly more force to the bottle neck. When satisfied with the position, thread the remaining hex nuts over the mounting plate and tighten them to hold the plate in position.
14. Drill two holes through the wood base along one side. The holes should be large enough to pass large spikes of metal tent stakes. When the launch pad is set up on a grassy field, the stakes will hold the launcher in place when you yank the pull cord. The launcher is now complete. (See page 90.)

Launch Safety Instructions:

1. Select a grassy field that measures approximately 30 meters across. Place the launcher in the center of the field and anchor it in place with the spikes or tent stakes. (If it is a windy day, place the launcher closer to the side of the field from which the wind is coming so that the rocket will drift on to the field as it comes down.)
2. Have each student or student group set up their rocket on the launch pad. Other students should stand back several meters. It will be easier to keep observers away by roping off the launch site.
3. After the rocket is attached to the launcher, the student pumping the rocket should put on eye protection. The rocket should be pumped no higher than about 50 pounds of pressure per square inch.
4. When pressurization is complete, all students should stand in back of the rope for the countdown.
5. Before conducting the countdown, be sure the place where the rocket is expected to come down is clear of people. Launch the rocket when the recovery range is clear.
6. Only permit the students launching the rocket to retrieve it.

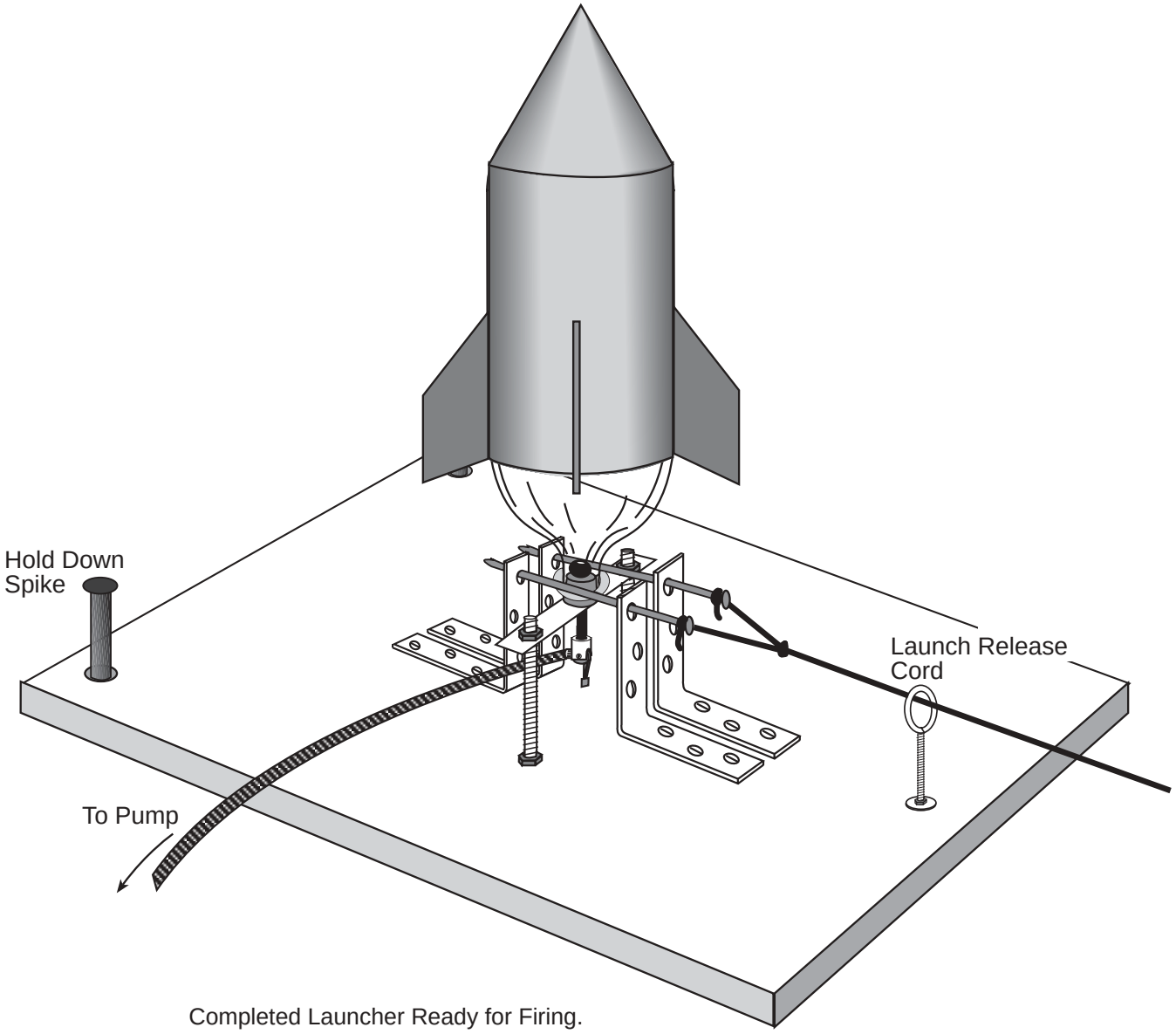
Extensions:

Look up the following references for additional bottle rocket plans and other teaching strategies:

Hawthorne, M. & Saunders, G. (1993), "Its Launchtime!," Science and Children, v30n5, pp.17-19, 39.

Rogis, J. (1991), "Soaring with Aviation Activities," Science Scope, v15n2, pp.14-17.

Winemiller, J., Pedersen, J., & Bonnstetter, R. (1991), "The Rocket Project," Science Scope, v15n2, pp.18-22.



Completed Launcher Ready for Firing.